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ABSTRACT

This teacher's guide on acid rain is divided into three study areas to explain: (1) what causes acid rain; (2) what problems acid rain has created; and (3) what teachers and students can do to help combat acid rain. Instructions for activities within the study areas include suggested grade levels, objectives, materials needed, and directions for the teacher. Many of the activities are science experiments or investigations. Experiments involve learning about acidity, the water cycle, sources of acid rain pollution, air-borne particles, acid rain's effects on aquatic life and plant seedlings, and the buffering capacity of types of soil. Other activities involve talking with people in the community, learning about the Clean Air Act, and writing letters to elected representatives. It is suggested that the activities could be incorporated into many subject areas and that a motivating study approach would be to organize the class into small study teams. A crossword puzzle, a glossary, and a bibliography of 17 journal articles, one filmstrip with cassette, one film, and one set of curriculum materials is included. (EM)

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ACID RAIN

A TEACHER'S GUIDE

ACTIVITIES FOR GRADES 4 TO 12

PUBLISHED BY THE NATIONAL WILDLIFE FEDERATION 1412 16TH ST., N.W. WASHINGTON, D.C. 20036

THE NATIONAL WILDLIFE FEDERATION CREED . . .

I pledge myself, as a responsible human, to assume my share of the stewardship of our natural resources.

I will use my share with gratitude, without greed or waste.

I will respect the rights of others and abide by the law.

I will support the sound management of the resources we use, the restoration of the resources we have despoiled, and the safe-keeping of significant resources for posterity.

I will never forget that life and beauty, wealth and progress, depend on how wisely we use these gifts . . . the soil, the water, the air, the minerals, the plant life and the wildlife.

The Acid Rain Teacher's Kit, item number 79678, may be purchased for $1.00. Please send check or money order to: The National Wildlife Federation, 1412 16th St., NW, Washington, DC 20036.

ACID RAIN
A TEACHER'S GUIDE

Ten years ago, few people had heard of "acid rain." But, today, it is one of our most talked about and serious environmental problems. It has killed the aquatic life in hundreds of lakes and streams throughout parts of the United States and Canada. It is also strongly suspected of damaging forests, some vegetable crops, buildings, and even human health. Already, acid rain has caused billions of dollars in damage.

The National Wildlife Federation has produced this acid rain teachers' activity guide because we believe that you and your students can help fight acid rain by learning more about it. The guide is divided into three study areas to explain:

1. What causes acid rain.
2. What problems acid rain has created.
3. How you and your students can help combat acid rain.

Each activity has a suggested grade level; however, most can be adapted to your students' level. You can also incorporate the activities into many subject areas, including science, art, language, and social studies.

For an exciting study approach, you can make your class into an "Acid Rain Task Force." Divide your students into small study teams and have each group choose to do one or more of the activities. At the end of the investigation, have each team present its findings to the rest of the class. This way, you can get all your students involved and teach more concepts in a shorter amount of time. Forming a task force to examine acid rain will also give your students a feeling of doing something worthwhile for themselves and their community.

I. WHAT IS ACID RAIN?

The acid rain problem begins at the smokestacks of coal-burning utilities and factories and the tailpipes of motor vehicles. The two main culprits are the man-made pollutants: **1)** sulfur dioxide (SO_2) from the coal-burning plants, and **2)** nitrogen oxides (NO_x) from car and truck exhaust.

Millions of tons of these pollutants are sent high into the atmosphere where they can travel hundreds of miles by wind. They can then react with water vapor to form sulfuric and nitric acids and then fall to earth as acid rain, snow, hail, and even fog.

To understand acid rain, it is helpful to understand 1.) the idea of acidity and 2.) the water cycle.

HOW ACID IS IT?

GRADE LEVEL: 7-12
OBJECTIVE: To understand acidity.
MATERIALS: pH paper (or other acid indicators), beakers or jars, common substances, marble chips, dirty pennies.

Briefly stated, a solution is more acid when it contains more hydrogen ions (H^+), or charged hydrogen atoms. Acidity is measured on a pH scale that ranges from 0 to 14; 0 is extremely acidic, 14 is extremely alkaline or basic, and 7 is neutral. The scale progresses logarithmically. Thus, pH 3 is 10 times more acid than pH 4 and 100 times more acid than pH 5.

You can measure pH in several ways, the pH meter being the most precise and, by far, the most expensive. Your high school chemistry laboratory might have one. Other indicators are less precise, less expensive, but still very useful. These include: **pHydrion papers,** wide range 0 (very acid) — 12 (alkaline), approximately $5.00, Carolina Biological Supply Company, Burlington, NC 27215 (800-547-1733); **Hach wide range** 0 (very acid) — 12 (alkaline), indicator kit, $56.75 plus postage and handling, Hach Chemical Company, Box 907, Ames, IA 50010 (1-800-247-3990); **Pocket Lab,** $2.95 plus postage, Early Winters, 110 Prefontaine South, Seattle, WA 98104.

To get an idea of acidity, fill small jars or beakers with common substances such as vinegar, ammonia, tap water, rain water, cola soft drink, lemon juice, and dissolved baking soda and measure their pH. The students can rank the substances on a bar graph, such as that on page 2 of the acid rain booklet in your kit. Then they can place small marble chips (obtainable from school chemistry labs) or pennies in each beaker and watch them for 48 hours. How does acidity affect the materials?

WATER REALLY GETS AROUND

GRADE LEVEL: 4-6
OBJECTIVE: To understand the water cycle.
MATERIALS: 1) Two glass containers, one with a waterproof seal.
2) Simple art supplies.

When water evaporates, it isn't gone forever. Instead, its molecules become an invisible gas and enter the atmosphere. Then, the water condenses into a liquid or solid and falls to earth again as rain, sleet, snow, and hail. If a molecule enters a stream, it might be drunk by a cow and become a part of the cow's tissue, until it is eaten by someone in a hamburger stand. This person can then perspire the molecule back to the atmosphere again. So, the world never really gains or loses water, it just recycles it.

1) To help your students understand this basic ecological concept, set up a simple water cycle in the classroom. Fill two clear containers with equal amounts of water. Cover one as tightly as possible and set them both aside. Watch the water levels for several days. Where has the water in the open container gone? How can the amount of water in the closed container be explained?

2) Using their imaginations, have your students create stories about the hypothetical "Life of a Water Molecule." Their stories can contain all the elements of a dime store adventure paperback—surprising twists of plot, drama, exotic travel, even intrigue and romance. Illustrate the stories by making large murals using butcher paper and paint, or adapt the stories into plays.

POLLUTION PATROL

GRADE LEVEL: 7-12
OBJECTIVES: To learn the sources of acid rain-causing pollution.
To learn how to get information from environmental agencies.

Ask one or more of your students to find out if your community has some factories or utility plants. If it does, your students can learn if any of them produce SO_2 pollution by contacting their state air pollution control office, usually located in state capitals (check with your local government for the address).

Next, determine the approximate amount of car-produced nitrogen oxides (NO_X) in your community. To do this you will need three figures: 1) the average amount of NO_X produced by each vehicle per mile, 2) the average length of each vehicle trip, and 3) the average daily number of cars on your community's roads. The first two figures are readily available because the EPA, in 1982, estimated average vehicle NO_X production as 4 grams per mile, and average trip distance as 5 miles per trip. To determine the third figure, the average number of daily cars on the road, your pollution patrol will have to collect some data itself. Here is how to do it:

1. Pick a point on a road that is neither overly congested nor traffic free and estimate the number of cars that pass that point in a day. You can do this by counting the number of cars passing the point in 15 minutes, multiply by 4 to get the number per hour and multiply by 24 to get the average per day. (Since each car travels an average of 5 miles, this figure indicates the number of cars in an average 5 mile segment of road.

2. Determine the number of 5 mile segments of road in your community by dividing the total number of miles of roads by 5.

3. Multiply the number of 5 mile segments in your community by the average number of cars in a 5 mile segment to get the total estimated number of cars using your community's roads in one day.

Since each of these cars produces 4 grams of NO_X per mile and each car travels an average of 5 miles, to estimate the total number of grams of NO_X produced per day in your community use this formula: number of cars on your community's roads in a day x 4 grams NO_X per car per mile x 5 (the average number of miles each car travels.)

Your class can also ask your county health department if your community has an air quality monitoring station it can visit. At the station, you should be able to see the filter that has trapped tiny air-borne particles in the station's air sampler, and compare its condition with a fresh filter, as well as observe the station's latest readings on SO_2, carbon monoxide, and ozone (the last two mostly coming from motor vehicle exhaust). The station official should be able to explain some of the pollutants' sources, daily and seasonal variations, and some public health ramifications.

WHAT'S IN THE AIR?

GRADE LEVEL: 4-9
OBJECTIVE: To learn about air borne particles in your area.
MATERIALS: Petroleum jelly, white paper, microscope slides, microscope.

Most air pollution is invisible, made up of microscopic particles and gases. Some air pollution, however, *can* be easily observed by doing this simple investigation. Cover two sheets of white paper with petroleum jelly and place them smear side up on an outside window ledge. Remove one after a day; leave the other a week. Compare the two sheets and record the differences. Your class might also want to compare sheets placed in other areas in the community, such as alongside highways, near factories, and in forests.

To observe particles more closely, repeat the procedure using microscope slides instead of paper. Under a microscope, observe the colors, shapes, and sizes of the particles. Can your students surmise where they came from? Your county health department should be able to help with answers.

II. WHAT DOES ACID RAIN DO?

It's hard to see acid rain's environmental effects, but you can simulate some of them with some simple classroom experiments.

WHAT'S IN THE WATER?

GRADE LEVEL: 7-12
OBJECTIVE: To see how acid rain can affect aquatic life.
MATERIALS: Pond water, dissecting microscope, 2-3 30 ml. petri dishes, pH paper, pump, large container, air stones, 250 ml. beaker, acid (vinegar), dip net, eyedroppers, household ammonia.

First, collect some invertebrates from nearby streams and ponds using dip nets or strainers. Try to get at least three of each kind. Put each type of animal that you collect in its own container (any jar will do) to minimize your animals eating each other. Collect also a good supply of water from your collection sources to help your catch survive in the classroom.

Once back, keep each type of invertebrate separate. Air stones and air pumps should ensure adequate oxygen. Insects collected from cold rushing streams, such as stoneflies and mayflies, are very sensitive to oxygen depletion and temperature increases. Keep these in a refrigerator with air stones. You can identify your catch using Elsie B. Klots' ***New Field Book of Freshwater Life,*** available from G. B. Putnam and Sons.

For each type of invertebrate, you will need three petri dishes. Fill each with the water from the places where each animal was collected and add one invertebrate to each dish. Measure the pH in each, then add 10-12 drops of vinegar to the first dish until the pH reads 4.0 and 4-8 drops of ammonia to the second until the pH reads 6.0. Leave the third dish as a control. Using a dissecting microscope, observe what happens to the aquatic life over 30 minutes. Repeat the procedure using different pH levels and different invertebrates. (If you can't get invertebrates from your vicinity, you can use daphnia or hydra, obtainable from biological supply houses. Be sure to check the policy in your school system first before experimenting with any invertebrates.) How does increased acidity or alkalinity affect the animals? Are all of them equally susceptible? If you have a variety of animals, you can prepare a chart illustrating their relative acid susceptibility. What happens to the fish, otter, osprey, and other large animals if small invertebrates are killed by acid rain? What happens to an entire aquatic ecosystem? (When the small invertebrates go, the small fish and other animals which eat them also die; the larger animals like otters go next. The loss of one food chain link affects the entire chain.)

HOW DOES YOUR GARDEN GROW?

GRADE LEVEL: 4-6
OBJECTIVE: To observe acid rain's effects on plant seedlings.
MATERIALS: Seeds (clover, radish, peas, mustard), paper cups, potting soil, vinegar, measuring cup, pH paper, lime tablets.

Plant each type of seed that you have in its own cup filled one inch from the top with potting soil. Plan on using 15 cups for each type of seed that you use. Water 1/3 of each group with tap or distilled water, 1/3 with water to which you've added vinegar to make the pH factor read 4.0, and 1/3 with lime added to make the pH 6.0. Observe the growth of the seedlings for two weeks. How does the acid water affect the plants? Is there a difference between different types of plants?

HAS ACID RAIN COME TO TOWN?

Acid rain has caused serious economic and environmental problems in many parts of North America. Has acid rain become part of your community? Your class can find out.

First, locate your area on the acid rain susceptibility map, pages 4 and 5 of the acid rain booklet in your kit. Even if you are in an area of low susceptibility, your community can still be suffering from acid rain. On the other hand, not all susceptible areas have experienced damage. You can find out if acid rain has come to your community by doing the following experiments.

GRADE LEVEL: 6-9.
OBJECTIVE: To determine the acidity of the rain in your neighborhood.
MATERIALS: Container (glass or teflon), pH paper, plastic garbage bag.

In a clean container, collect some rain, snow, or sleet during the next storm. During collection place the container upon a plastic garbage bag to prevent dirt and other materials from splashing into your sample. Measure the sample's acidity using pH paper. If your rain has a pH below 5, acid-causing pollutants have probably affected it. Repeat the process several times, relating different acidity levels with wind direction (obtained through your local newspaper or weather station). This may indicate where acid rain-causing pollution, if any, is coming from.

Many communities have acid rain monitoring stations, some maintained by state air pollution offices, others by the Bituminous Coal Research Inc.

At a station, you can ask whether your community is experiencing acid rain, what its probable sources are, and how much damage it has caused. You might also compare your rain acidity testing results with the station's. If your results differ, your figures aren't necessarily inaccurate; different testing sites can gather different data. To test your data's accuracy, compare the acidity of some rain you have collected yourself at the monitoring station with the station's samples and adjust accordingly.

To learn if a station exists near you, contact your county health department, or your state air pollution control office or:

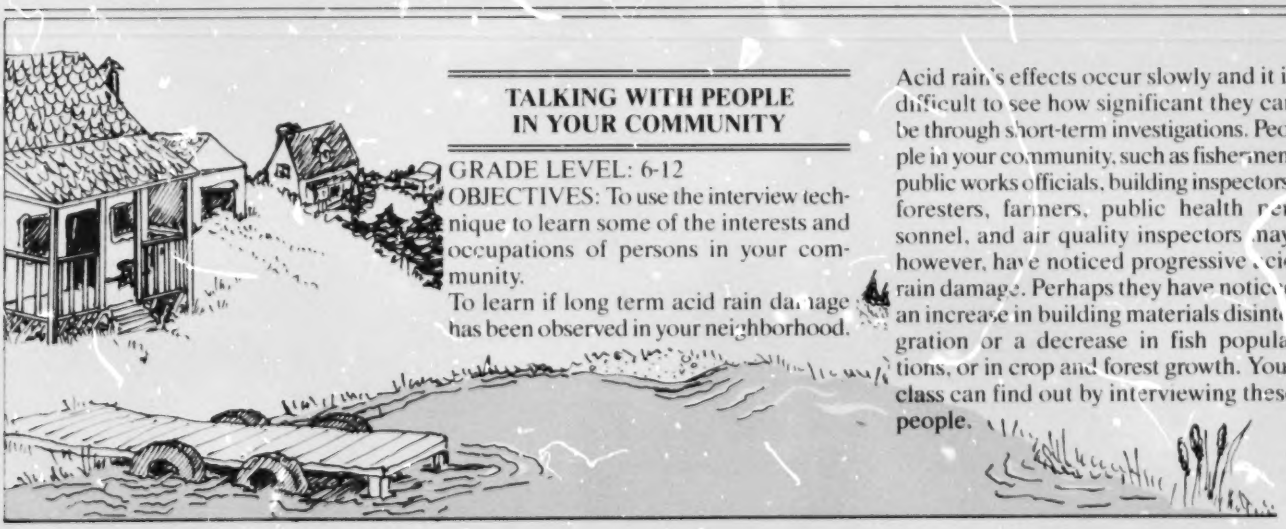
Bituminous Coal Research Inc.
350 Hochberg Road
Monroeville, PA 15146 (412) 327-1600

CAN THE SOIL COPE?

GRADE LEVEL: 6-9
OBJECTIVE: To learn that the buffering capacity of soil varies with soil type; to learn that the buffering capacity of soil affects the environmental impact of acid rain.
MATERIALS: Small plastic garbage bags, soil samples, funnels, filter paper, beakers, pH paper, vinegar, large containers.

Acid rain can completely eliminate life in lakes, streams, ponds, and even rain pools. However, the amount of damage it does depends largely upon an area's soil. Rainwater trickles through soil to the groundwater and then can enter lakes and streams. Only alkaline soils can neutralize or buffer the rain's acid. Unfortunately acid rain is striking many areas which have soils incapable of buffering the acid. These areas include nearly all of eastern Canada, New England, New York's Adirondacks, parts of the Appalachians, and much of Minnesota, Michigan, and Wisconsin.

To determine the buffering capacity of your area's soil, your class can conduct the following experiment. First, contact your Soil Conservation Service District Office to learn the location of different types of soil in your vicinity. Collect samples from these locations in small plastic bags. Back in the classroom, make funnels from bleach bottles and put the filter paper in the bottom of the funnel. Now fill each funnel with 1 pound (approximately 450 grams) of a different soil sample and place them over the large containers. Next, add 50 ml. of vinegar to 150 ml. of water to make a solution with a pH of 4.0. Pour it over the soil samples, and measure its pH again, once it has percolated through the soil into the container. Compare the results to determine which soil has the best buffering capacity. Your local Soil Conservation Service agents should be able to help you with some explanations.



TALKING WITH PEOPLE IN YOUR COMMUNITY

GRADE LEVEL: 6-12
OBJECTIVES: To use the interview technique to learn some of the interests and occupations of persons in your community.
To learn if long term acid rain damage has been observed in your neighborhood.

Acid rain's effects occur slowly and it is difficult to see how significant they can be through short-term investigations. People in your community, such as fishermen, public works officials, building inspectors, foresters, farmers, public health personnel, and air quality inspectors may, however, have noticed progressive acid rain damage. Perhaps they have noticed an increase in building materials disintegration or a decrease in fish populations, or in crop and forest growth. Your class can find out by interviewing these people.

III. WHAT CAN YOU DO?

Dirty air and acid rain can provide one useful product: an excellent social studies teaching tool! By observing how the Clean Air Act is faring in Congress, students can learn how laws are made and how our governmental system works.

THE CLEAN AIR ACT

In 1983, the United States Congress will revise the 1970 Clean Air Act Amendments. This law, and its amendments passed in 1977, require the U.S. Environmental Protection Agency to:

1. Set health standards regulating the amounts of seven different air pollutants* to be permitted in the atmosphere.
2. Set standards regulating the amounts of pollutants that certain sources—factories, motor vehicles, utilities, etc.—can emit.
3. Ensure that all states develop plans to meet Federal Air Quality Standards.
4. Enforce compliance with air quality standards.

The bill stated that in 1981 the act would come up for revision, a process still underway in 1983.

Here's what happens in the revision process: A bill is introduced to the House and Senate and then assigned to the appropriate committees. In this case, the Clean Air Act was directed to the House Energy and Commerce Committee and the Senate Environmental and Public Works Committee. Subcommittees within each committee hammer out the bill's details and then refer their recommendations to the full committees. Following this, the House bill travels to the House Rules Committee and the Senate bill to the Senate floor. The House Rules Committee decides how the bill will be handled in the House--how much debate will be allowed, how many amendments can be added, when it will be considered. Now on each chamber's floor, the measure is voted upon by the complete legislative bodies. If each passes its bill, it ends up in the Conference Committee, consisting of members of both chambers. Usually by this time, each body has altered its respective version making each one different. The Conference Committee makes each version identical in a manner that will, hopefully, be acceptable to both chambers. Both houses then vote upon this version. If it passes, it lands upon the desk of the President of the United States who can either sign it into law or veto it. Only a 2/3 majority in both the House and the Senate can override this veto.

This process is illustrated on page 8.

Everyone wants clean air. Why, then, have the Clean Air Act revisions now before Congress become so controversial?

Basically, the argument revolves around the question: At what point do the costs of cleaning America's air become too expensive for the benefits gained? Some people claim that the air quality standards we already have are too strict. They contend that industry, electric utilities, and motor vehicle manufacturers are paying too much to reduce their air pollution, thus harming the economy and placing an unfair financial burden upon them and the consumer. As far as acid rain goes, they feel we don't know enough yet to blame man-made pollution for acid rain. They maintain that we should learn more about how acid rain is formed before investing a lot of money to solve the problem.

But many people disagree with this point of view and think the evidence associating acid rain with SO_2 and NO_x emissions is overwhelming. While agreeing that it will cost money to reduce these pollutants, they maintain that continued acid rain damage to aquatic ecosystems, forests, vegetable crops, and public works will cost even more. Besides which, they claim, enormous costs exist which cannot be adequately expressed in dollars and cents, such as the loss of recreational fishing.

Who's right? By deciding for themselves and then acting upon their opinions, your students can learn some fundamental responsibilities of living in a democracy and some of the roles they can play to help this democracy function. With the clean air question, they face a problem not easily resolvable by laymen. There are ways, however, that they can approach it.

First, your students can consider the problem in depth. The acid rain booklet in your kit represents one perspective; another view may be heard either by contacting local utilities or by writing a utility trade association, the Edison Electric Institute, 1111 19th Street, N.W., Washington, DC 20036. Your students might also want to hear from people in the community (such as those described in the last section) or consult their local newspapers. Your class can cut out newspaper articles and place them in an acid rain notebook or classroom corner. Alongside these clippings can be recent magazine articles on the subject. Check the bibliography for some sources.

Also, a film, "Acid Rain—Requiem or Recovery," has been sent to each PBS television station in the country. Quite possibly, the station in your neighborhood will show this film during school hours if sufficient interest exists. Try calling the station and enlisting the help of other schools in the effort. The film lasts 27 minutes and is an excellent introduction to acid rain. To complete an hour, your station might sponsor a debate on the subject.

After researching the subject, have your students consider:

1. How does acid rain affect them and their community?
2. What are the costs of controlling acid rain vs. the costs of leaving it unchecked? (Expenses to utilities, car

Sulfur dioxide, total suspended particulates, carbon monoxide, nitrogen oxides, hydrocarbons, ozone, and lead.

manufacturers, industry, and the consumer on one side; health costs, loss of crops, forests, fishing, and recreation revenues; and damage to buildings on the other.) Which costs cannot be adequately expressed in financial terms?
3. How do you decide if sufficient evidence exists concerning acid rain formation and acid rain damage to justify doing something about the problem? (One possibility: consider the sources of information. How impartial are they?)
4. Which types of organization support each side? Do they have vested interests in the outcome of this issue? See the partial list below:

For Weakening Air Quality Standards

American Coal Association
United Mine Workers
Edison Electric Institute
Appalachian Power Company
Wheeling Electric

For Strengthening Air Quality Standards

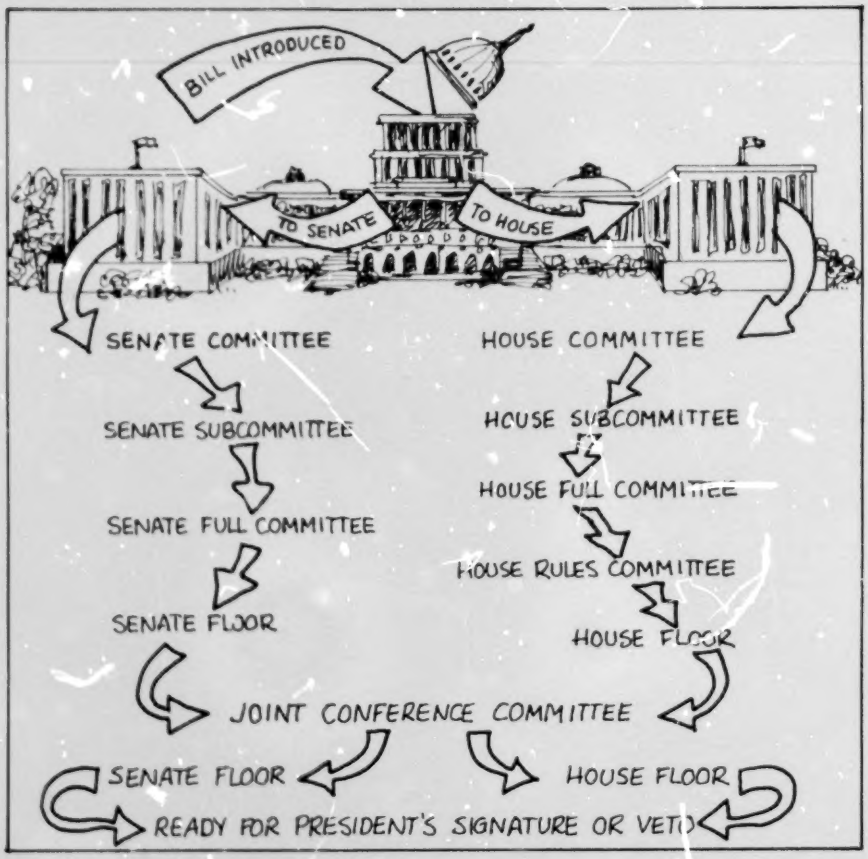
National Wildlife Federation
League of Women Voters
American Lung Association
United Steelworkers of America
American Forestry Association
American Fisheries Society
Trout Unlimited
American Public Health Association
National Farmers' Union

WRITING A LETTER

GRADE LEVEL: 6-12
OBJECTIVES: To learn how to write a letter to elected representatives;
To demonstrate that Congressmen consider such letters to accurately reflect their constituents' concerns.
To encourage future participation in legislative processes.

Once your students have taken a position on the Clean Air Act, they are ready to have their voices heard. Through writing their representatives, senators, or even the President, they can learn that our legislators rely, to a great extent, upon their mail to know what their constituents think. The viewpoints, in turn, affect how our elected officials vote.

Your students can write to their representatives at the following addresses:



(Your representative in the House)
c/o House of Representatives
Washington, DC 20515

(Your senators)
c/o U. S. Senate
Washington, DC 20510

The President
c/o The White House
Washington, DC 20500

Your students can learn the Act's current status by contacting their congressman's local office. But what about after the Clean Air Act? Whatever happens, it will take years to implement its revisions, leaving the door open for further policy changes. Continued tracking of your representatives and media on this issue, then, will still be an interesting study of the legislative process.

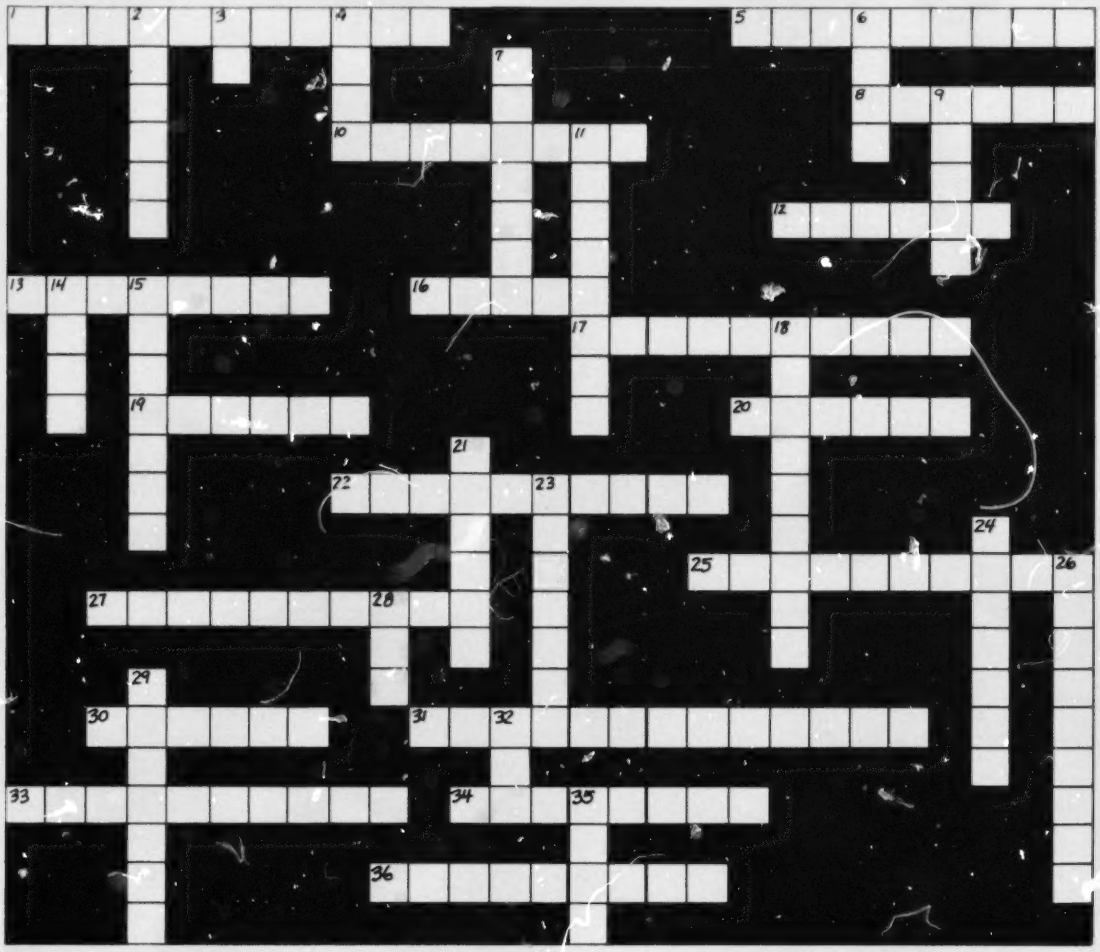
A brief note on the National Wildlife Federation's attitude towards this activity. Obviously, the Federation is committed towards working for a strong Clean Air Act that significantly decreases acid rain-causing pollution. Nevertheless, we realize that, for this activity to be of educational value, each student has to make up his or her own mind. Even if students end up disagreeing with the Federation; we are convinced that the value of this activity in teaching students to be good citizens makes it worthwhile.

LET'S TALK

GRADE LEVEL: 6-12
OBJECTIVES: To develop skills in organization, debate, writing, art and design, and communication.

Many exciting communication projects on acid rain are possible, including:
1. Holding a debate among your students for others in the school, with votes being taken afterwards on the issue.
2. Sponsoring a forum of available speakers on acid rain, including scientists, fishermen and guides, public works officials, utility and coal company spokesmen, and members of conservation groups.
3. Writing columns and articles in the school and town newspapers.
4. Constructing acid rain exhibits in the hallway or classroom.
5. Sponsoring an acid rain poster contest in your school or community.
6. Contacting your local T.V. and radio stations and newspapers asking them to include acid rain information in their weather reports. The National Wildlife Federation has prepared a "media kit" which can assist the media in expanding their weather reports in this manner.

ACID RAIN CROSSWORD PUZZLE



ACROSS

1. _____ transport is when prevailing winds carry pollutants miles from their source.

5. _____ capacity is the degree to which soils or water bodies can neutralize acids.

8. _____dioxide and nitrogen oxides are two kinds of pollutants involved in acid rain formation.

10. _____oxides and sulfur dioxide are two kinds of pollutants involved in acid rain formation.

12. A _____ lake is a lake that has no aquatic life.

13. A _____ is a device added to power plants to remove certain materials from coal fired emissions.

16. Some experts consider fossil _____ such as coal to be the root of the acid rain problem.

17. _____ and utility smokestacks and automobile exhausts emit sulfur dioxide and nitrogen oxides that contribute to the acidity of rain.

19. Lake _____ is a temporary costly method of dumping calcium compounds in lakes to neutralize the acid.

20. The U.S. and _____ are two countries that share the problem of acid rain.

22. Limestone soil has the ability to _____ the acidity of rain.

25. Communities of independent organisms together with the environment in which they inhabit and with which they interact are called_____.

27. At least 200 _____ lakes that once had fish are now fishless.

30. To _____ is to neutralize (partially) acidic precipitation in soils or waters.

31. Sulfur dioxide and nitrogen oxides are mixed with moisture falling to earth as _____.

33. Sulfur dioxide and nitrogen oxides are _____.

34. Buffering _____ is the degree to which soil or water bodies can neutralize acidification.

36. An ecosystem is a community of independent _____ together with the environment which they inhabit and with which they interact.

DOWN

2. Acid rain is formed from two kinds of pollutants, sulfur dioxide (SO_2) and nitrogen _____.

3. _____ paper is used to measure the acidity of soil or H_2O.

4. _____ is considered abnormally acidic if its pH falls below 5.6.

6. Some _____ will die when the pH factor has fallen to 4.5.

7. Sulfur _____ and nitrogen oxides are two kinds of pollutants that form acid rain.

9. More than 200 _____ in the Adirondacks that once had fish are fishless due to acid rain.

11. _____ refers to the discharge of substances into the air through industrial smokestacks and car exhausts.

14. Some experts believe that the burning of fossil fuels, such as _____ is the root of the acid rain problem.

15. Sulfur dioxide is emitted primarily from industrial and _____ smokestacks.

18. Prevailing winds can _____ pollutants thousands of miles from their source.

21. Utility and smelter smoke_____ emit pollutants.

23. When the pH of a lake falls below 4.5 most _____ life will be dead.

24. The type of _____ of a lake determines its ability to neutralize acid precipitation.

26. Congress will soon be voting on a bill revising the _____ set for clean air and water.

28. Acids and other pollutants are cleansed from the _____ by rain, snow and other forms of precipitation.

29. Air _____ standard is the prescribed attainable level of a pollutant established by Federal and state governments.

32. _____ Environmental Protection Agency, is the government agency charged with enforcement of Federal air and water pollution regulations.

35. _____ rain is formed when sulfur dioxide and nitrogen oxides combine with moisture in the air.

Solution to puzzle on page 11

G L O S S A R Y

Acid A material with a pH of less than 7.0.

Adirondacks A mountainous lake area in New York State where acid rain has caused over 200 lakes to be fishless.

Air Quality Standards Federal and state government-prescribed levels of a pollutant in the outside air that cannot be exceeded during a specified period of time in a specified geographical area.

Alkaline Capable of neutralizing acid and producing hydroxyl (OH) ions in solution.

Aquatic life Plants or animals living in water.

Bedrock The solid rock found on the surface of the land or just below the soil.

Buffer The ability to (partially) neutralize acidic precipitation in soils and waters.

Buffering capacity The degree to which soils or water bodies can neutralize acidification.

Carbonate A mineral, soluble in acid, the chemical composition of which contains CO_3.

Carbon monoxide (CO) A colorless toxic gas produced by incomplete fossil fuel combustion, notably in motor vehicles.

Ecosystem A community of independent organisms together with the environment with which they live and interact.

Emission Substances discharged into the air through smokestacks and car exhaust.

EPA The Environmental Protection Agency is the governmental agency that enforces Federal regulations concerning pollutants.

Fossil fuels Fuels derived from organic substances such as coal, petroleum, and natural gas.

Ion An electrically charged atom or group of atoms.

Lake liming Dumping alkaline compounds into a lake to neutralize the acidity of its water.

Molecule The smallest particle of an element or compound that can exist alone and retain the characteristics of the substance.

Nitrogen oxides (NO_X) Gases formed in great part from atmospheric nitrogen and oxygen when combustion occurs at high temperatures.

Organism Any animal or plant which can maintain life on its own.

Osprey A large, fish-eating bird of prey.

Ozone (O_3) A form of oxygen that is reactive chemically and an irritant to the eyes and respiratory system.

Percolation The downward movement of water through soil.

pH The measuring unit for specifying the acidity of a substance.

Precipitation Moisture that falls to the earth such as snow, rain, sleet, etc.

Scrubber A device (attached to a utility or industrial smokestack) that uses a liquid spray to remove aerosol and gaseous pollutants from an airstream.

Standards The amount of pollutants allowed by state and Federal governments.

Sulfur dioxide (SO_2) A pungent, colorless gas formed primarily by combustion of fossil fuels.

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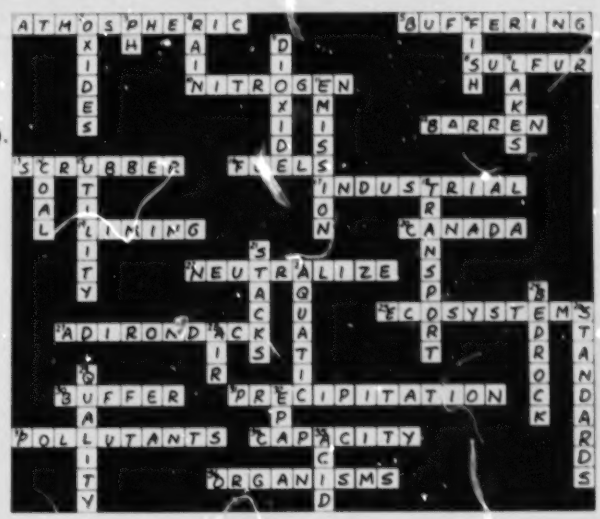
FILMSTRIP
"Acid Rain—The Choice Is Ours,"
by Friends of the Boundary Waters. 80 frame filmstrip with cassette, catalog #52-3442, $36.50, from Carolina Biological Supply Company, Burlington, NC 27215 (800-547-1733).

FILM
"Acid Rain—Requiem or Recovery,"
16mm, 27 min., color, free, from National Film Board of Canada, Suite 313, 111 E. Wacker Dr., Chicago, IL 60601

CURRICULUM MATERIALS
Laboratory and classroom activities for science, social studies, and environmental science, Grades 7-12. $50.00 for 5 units, from Acid Precipitation Awareness, 1037 Bidwell St., West St. Paul, MN 55118 (612-455-7719).



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